THE ONTARIO POWER Co of NIAGARA FALLS

On 8

VISITORS are admitted to the plant, accompanied by a guide, between the hours of 9.00 A. M. and 5.00 P. M. For this privilege a nominal charge is made, part of which is used to pay for the services of guides, and the remainder applied to the support of a bed in the Niagara Falls General Hospital.

Certain portions of the plant are inaccessible to visitors, due to the extremely high voltage used, and also from the danger of allowing their presence to interfere with its efficient operation.

THE ONTARIO POWER COMPANY OF NIAGARA FALLS

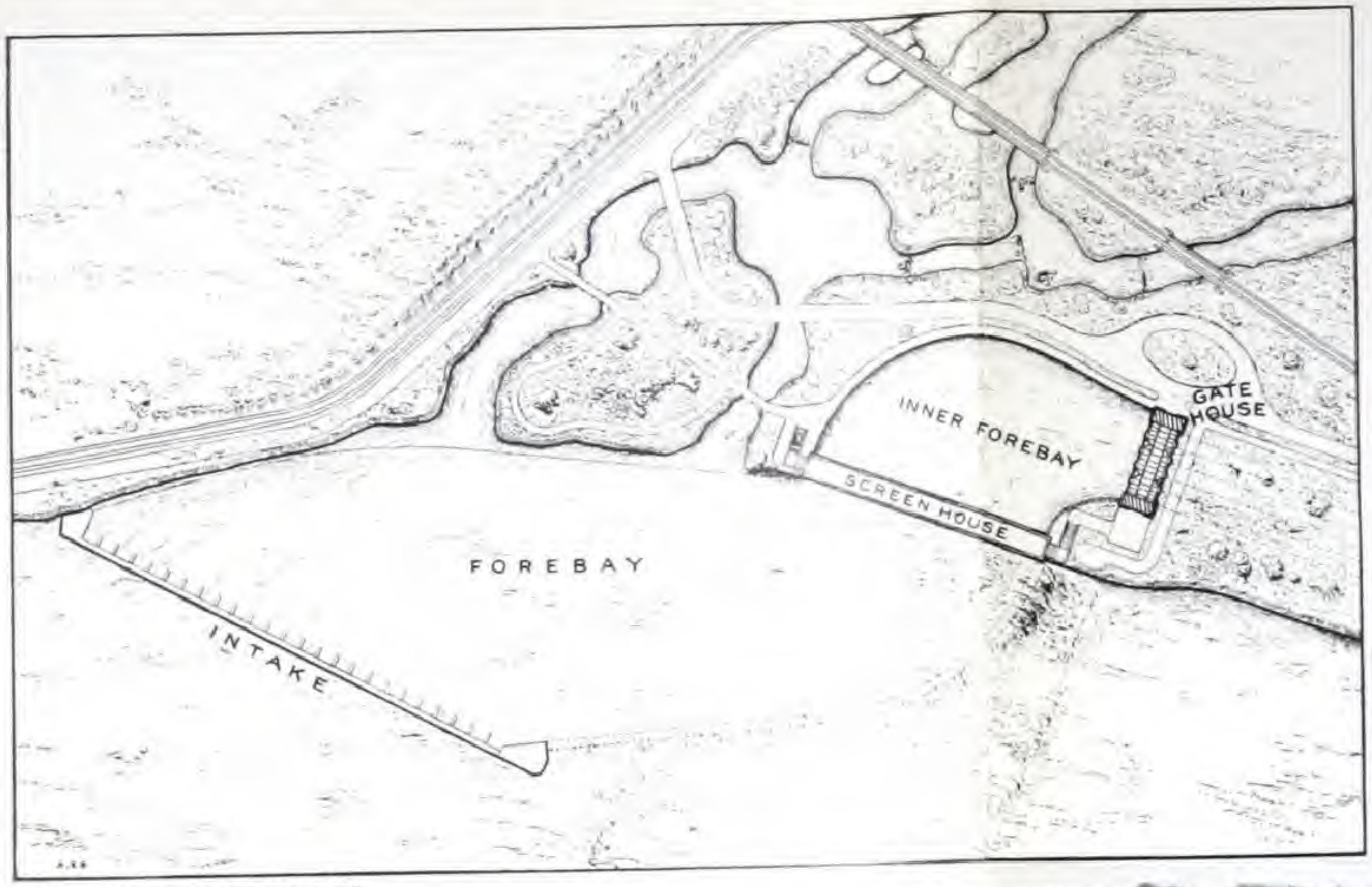
BIRD'S-EYE VIEW OF NIAGARA FALLS SHOWING POWER DEVELOPMENT ON CANADIAN SIDE

THE falls of Niagara have long been recognized as a possible source of immense power, and, in fact, were utilized in a small way by the early settlers of the district. They, however, were unable to utilize the main falls and so confined their operations to the rapids. Here they built saw mills and grist mills and thus took the first steps in the harnessing of Niagara.

Modern conditions, with the wonderfully flexible means of distributing and utilizing large amounts of energy, embodied in the use of electricity, call for methods of development far different from those used by the early settlers. In place of the small amount of power needed for grinding corn or sawing logs, there are now required thousands of horse power for the performance of a myriad of tasks. The few feet of head which satisfied the settlers' needs must now be increased to the maximum possible to obtain. In place of the breast or overshot wheel we now have the highly efficient modern turbine.

Among these modern power plants which are everywhere thus beginning to make efficient use of the energy supplied by nature in the form of falling water, that of The Ontario Power Company of Niagara Falls is one of the most recent, and the largest.

The general plan of the Company's development is as follows. Water is taken from the river at a point on the Canadian shore about a mile above the crest of the Horseshoe Fall, and just above the rim of the first cascade of the upper rapids. After being thoroughly freed from floating ice and debris, it is conveyed, through steel conduits laid underground and steel



PLAN OF INTAKE WORKS

penstocks tunneled through the solid rock, to the Generating Station situated at the base of the cliff below the Horseshoe Fall. The electrical energy here generated by means of turbines and generators is transmitted by underground cables to the Distributing Station located high on the bluff above. From this station radiate the transmission lines which convey the power to the manifold enterprises depending upon it.

In the winter and spring large quantities of ice come down the river, floating on the surface for the most part but with enough suspended in the water to impede the successful operation of the plant, were it not removed at the head-works. For this purpose a long intake dam stretches out into the river in a down-stream direction, almost parallel to the current, admitting to the forebay only the water at the bottom of the river, while ice and floating debris are carried to the rapids by the swift current that sweeps along its outer face. In the comparative quiet of the outer forebay more ice rises to the surface to be similarly skimmed off at the screen house, where the water is further cleansed by heavy iron screens. At the gate house the water is again skimmed and finally admitted to the main conduits through large electrically operated gates. The design of these intake- or head-works is as unique as their operation is successful. During the three winters that they have been in operation there has not been a moment's interruption from ice — a record which is unprecedented for

FOREBAYS, SCREEN HOUSE, AND GATE HOUSE

RETURN OF WATER TO RIVER OVER SUBMERGED WALL

INTERIOR OF EIGHTEEN-FOOT CONDUIT DURING CONSTRUCTION

power plants in a climate like that of Niagara. The gate house contains the gates, electrically operated, which regulate the flow of water from the inner forebay to the conduits. One of the gates was completed in 1905, and two more will be required for the complete development.

From the gate house enormous steel conduits (one of which has been in use since 1905, and two more will be built when required) lead the water underground through Queen Victoria Park for over a mile to the overflow, located a short distance beyond the Horseshoe Fall. The purpose of this overflow is to prevent water hammer in the conduit, in case of a sudden decrease in the amount of water required for power, by allowing the surplus to spill harmlessly into the river through a tunnel excavated for that purpose.

Underneath the last 260 feet of the present conduit (known as the "Distributor Section") steel penstocks, nine feet in diameter, lead vertically downward, through electrically operated valves located in a room hollowed out of the rock, to a level slightly below that of the Generating Station floor, then, turning at right angles, lead horizontally to the turbines. Each penstock supplies one turbine unit.

From the turbines, the water is discharged through draft tubes, and returns to the river under the outer wall of the Generating Station.

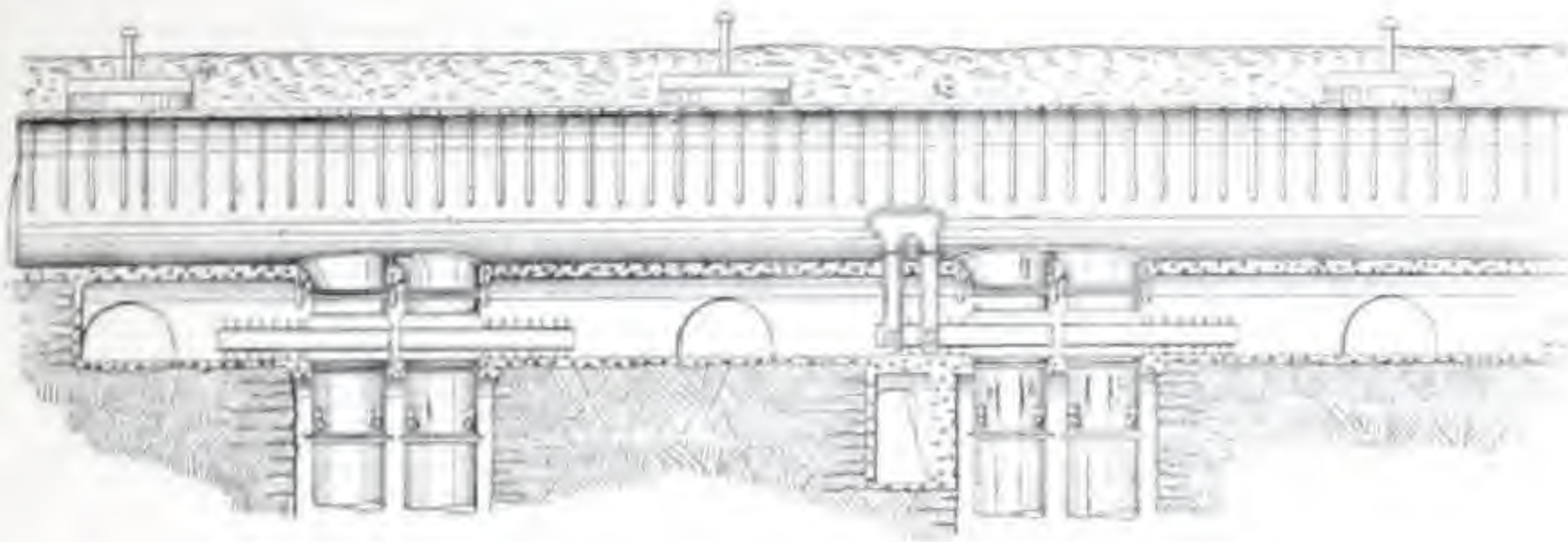
At present, six generators are installed, three of 10,000 horse power each and three of 12,000 horse power each, all being of the horizontal-shaft type and directly connected to the balanced twin turbines. Two direct-current turbine-driven dynamos on the gallery supply the exciting current for the large machines.

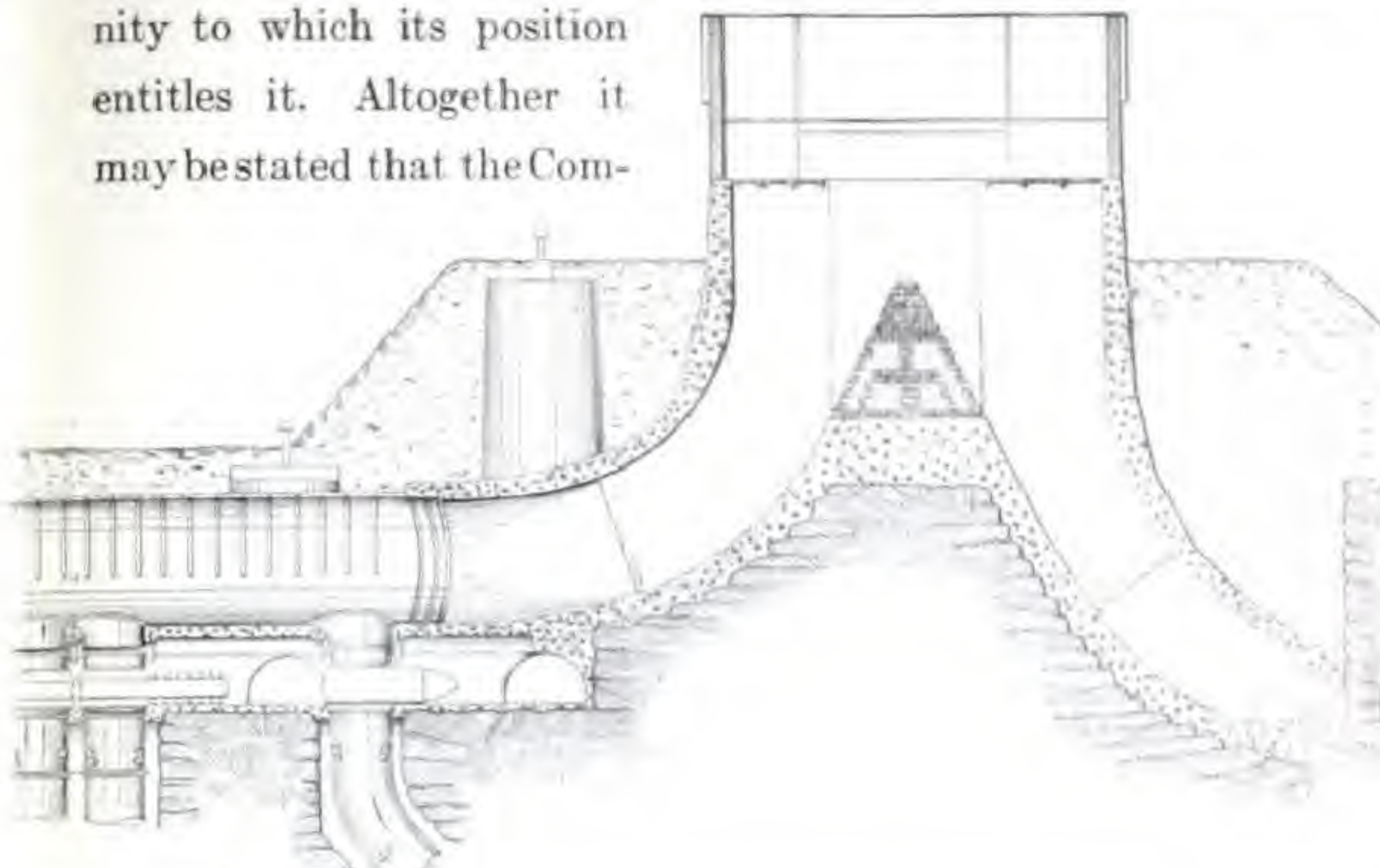
A cable tunnel and conduit system lead from the Generating Station to the Distributing Station on the hill. The electrical power is thus conducted in lead-covered cables to the bus-bars. These cables and bus-bars are to the electrical system what the

EXTERIOR OF EIGHTEEN-FOOT CONDUIT DURING CONSTRUCTION

NIAGARA FALLS AND IMMEDIATE VICINITY.

main conduit and distributor section are to the hydraulic system. At the bus-bars, the power is divided up, and led through cables to the transformers, where the voltage is stepped up from 12,000 to 60,000 volts. At this voltage it is sent out on the lines, some of it going as far as Syracuse, N. Y., one hundred and sixty miles away. The power for use in Canada is sent out untransformed, at 12,000 volts, to the many indus-





SECTION THROUGH VALVE CHAMBER AND OVERFLOW

tries in the vicinity of the plant and along the Welland Canal.

In the central compartment of the Distributing Station are grouped all the devices for operating the various oil switches, and for controlling the voltage and speed of the generators. Here also, are the meters, which not only show what is occurring at each instant in the power circuits, but record it for future reference. Here, too, is the central switchboard of the private telephone system, over which it takes but an instant to call up any station on the network of power lines. This system of central control is original with this plant, and, like the scheme for diverting ice at the intake works, is as successful as it is unique.

Throughout the company's works no pains have been spared to preserve the beauty of the Park and the integrity of the Falls. The intake is so located and constructed as to raise rather than lower the level of the upper river. Screen and gate houses have been carefully designed to befit their location. New islands have been created and new vantage points provided for viewing the falls and rapids, all of which are perfectly free and open to the public use. All unsightly constructions, which by their nature could not be made beautiful, have been placed out of sight under ground. The Generating Station so blends itself into its background as to be almost unnoticeable. The Distributing Station, from its location necessarily a conspicuous object, has been treated with the dignity to which its position entitles it. Altogether it may be stated that the Company has expended close to a million dollars in this work, from which it receives no return but the approval of the visiting public.

THE PLANT IN DETAIL

FALLS AND RIVER

The total drop in the Niagara River in its course of 36 miles between Lake Erie and Lake Ontario is 326 feet, of which 216 feet is in the falls and the rapids immediately above them.

The American Fall is 167 feet high and 1,000 feet in width, while the Horseshoe Fall is 159 feet high and 2,600 feet in width. The greatest depth of the river immediately below the falls is about 192 feet.

ENTRANCE AND OVERFLOW BUILDINGS

It is estimated that an average of 222,400 cubic feet of water pass over the falls each second. This is 25,000,000 tons an hour, or about one cubic mile a week, and represents a kinetic energy of nearly 5,000,000 horse-power.

HEADWORKS

At the headworks of The Ontario Power Company, the river is 3,400 feet wide, and flowing at an average velocity of about 8 feet per second.

THE INTAKE, constructed of reinforced concrete, is nearly 600 feet long, and is divided into twenty-five bays. The concrete curtain, which deflects the surface current, extends 9 feet into the water, which is here 15 feet deep. Through these bays or openings in the intake, water is admitted to the outer forebay with an entering velocity of 5 feet per second. Provision is made for inserting stop logs into each of the twenty-five openings in order to regulate the flow of water.

THE OUTER FOREBAY, having an area of 8 acres and a depth ranging from 15 to 20 feet, is bounded on its down-stream side by a submerged wall or dam, over which a large part of the water which enters the forebay is returned to the upper rapids, bearing with it such ice and debris as succeed in passing the intake curtain. This wall is 725 feet long and terminates at the down-stream end of the screen house.

THE SCREEN HOUSE is 320 feet long, built of reinforced concrete faced with "Roman Stone." Broad, ornamental stairways at either end lead to the roof, where a spacious promenade, open to the public at all times, commands a magnificent view of the upper rapids. The water at the screen house is 20 feet deep. A five-foot concrete curtain wall again admits only deep water through the screens to the inner forebay.

THE INNER FOREBAY forms a quiet pool of 2 acres area and 20 to 30 feet depth, where the water has a final opportunity for being cleared of foreign matter, before entering the conduits.

THE GATE HOUSE, similar in construction to the screen house, is 120 feet long and divided into six bays, two for each main conduit. The eighteen-foot "Stoney" gates which guard the entrances to the conduits weigh 18 tons each, or 36 tons including the counterbalance. They were built by Ransomes and Rapier of London, England, and are operated by electric motors of 5 horse-power capacity.

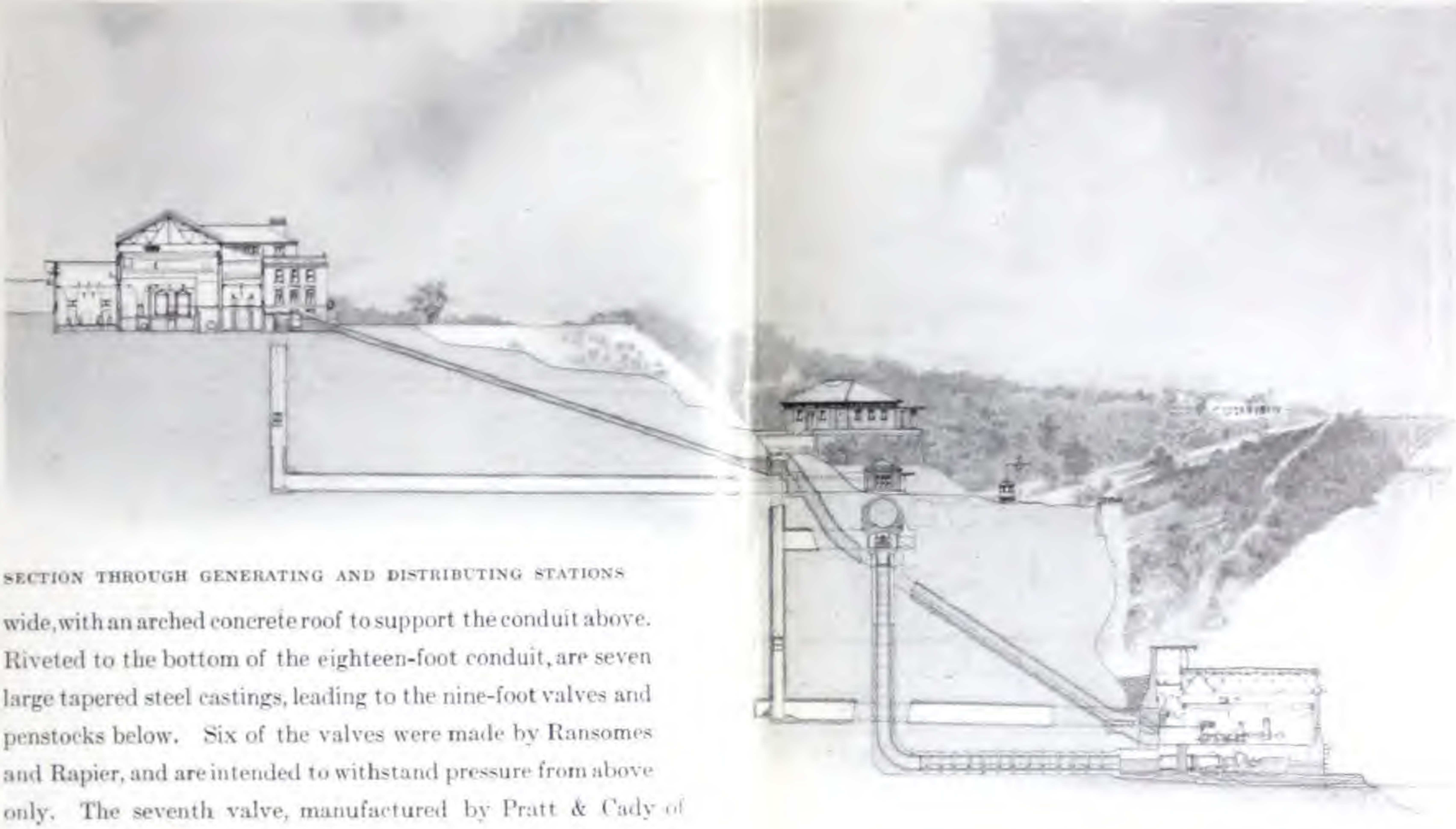
CONDUITS AND PENSTOCKS

NO. 1 MAIN CONDUIT is 18 feet in diameter, 6,300 feet long, 254 square feet in cross-sectional area, and is made of half-inch steel plates with stiffening rings half way round the top at intervals of 4 feet throughout its length. It is entirely encased in concrete, and covered to a depth of from 4 to 10 feet with earth and rock back-fill. At full load this conduit will supply sufficient water for the operation of six generators. The second and third conduits have not as yet been installed.

THE OVERFLOW consists of a massive structure of reinforced concrete, containing an adjustable weir of stop-logs, over which surplus water is discharged through a spiral tunnel to the lower river. The building is finished with a facing of rubble stone, and has a broad promenade commanding an unusual view of both Canadian and American Falls.

THE VALVE CHAMBER is 274 feet long, 10 feet high and 16 feet

GENERATING STATION, OVERFLOW, AND DISTRIBUTING STATION AS SEEN FROM GOAT ISLAND



SECTION THROUGH GENERATING AND DISTRIBUTING STATIONS

wide, with an arched concrete roof to support the conduit above. Riveted to the bottom of the eighteen-foot conduit, are seven large tapered steel castings, leading to the nine-foot valves and penstocks below. Six of the valves were made by Ransomes and Rapier, and are intended to withstand pressure from above only. The seventh valve, manufactured by Pratt & Cady of Hartford, Conn., is built to withstand pressure on either side. Each valve is operated by a thirty horse-power induction motor, controlled either locally or from the switchboard in the Generating Station, and may be fully opened or closed in three minutes.

THE PENSTOCKS are 307 feet long on the center line and 9 feet inside diameter, built of steel ¾ inches thick at the top and ⅞ inches at the bottom. Shafts and tunnels, two penstocks in each, carry them to the Generating Station. The lower 60 feet of each shaft is filled in with concrete around the penstocks, as the rock here is soft shale.

GENERATING STATION

The mean water level here is 343 feet above tide, though it varies from 338 to 365. The walls of the Generating Station are of concrete, the rear wall being 12 feet thick at the bottom, and the river wall, 9 feet.

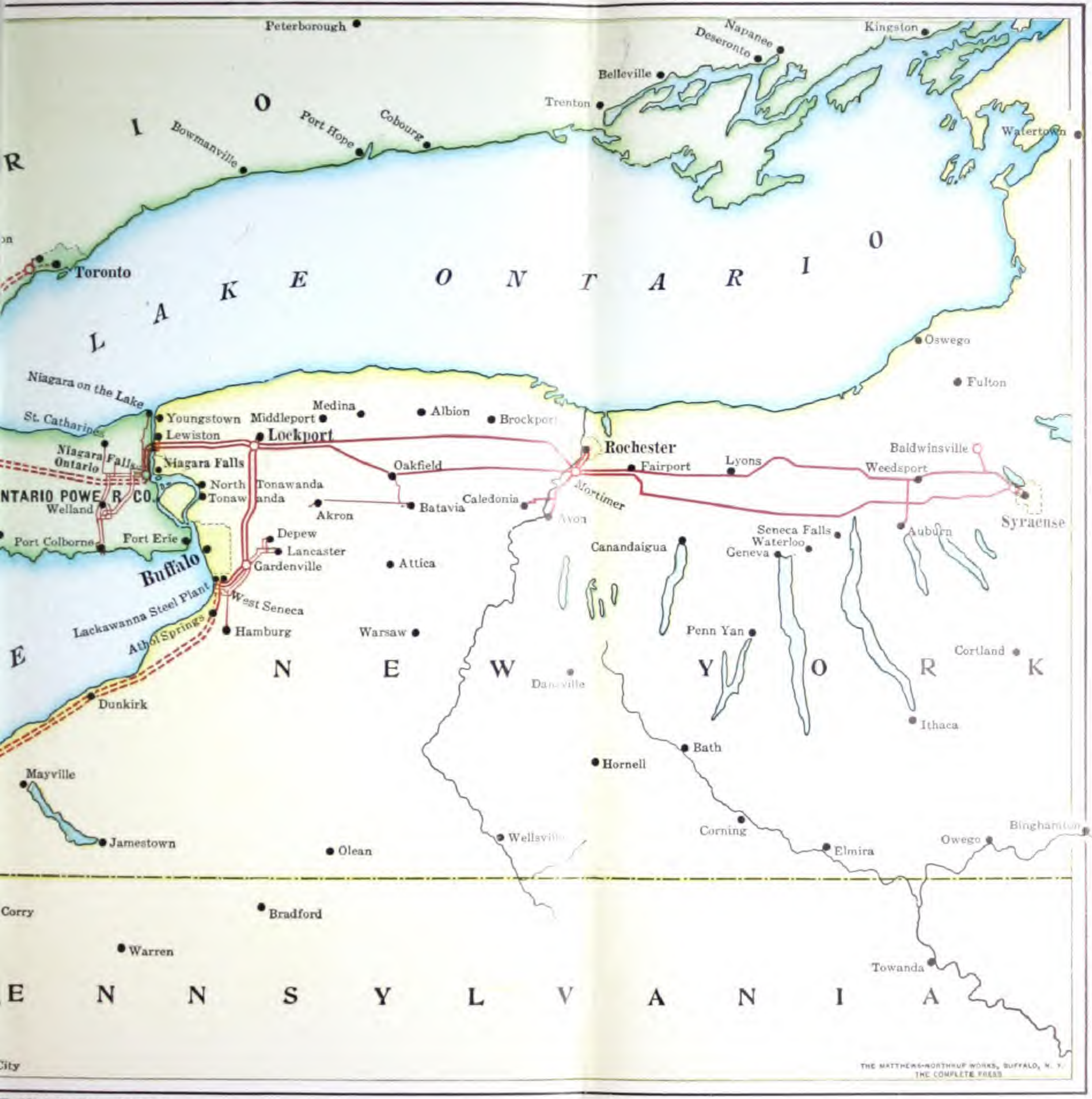
THE TURBINES are of the inward-flow horizontal twin type, manufactured by J. M. Voith, Heidenheim a. d. Brenz, Germany. Their capacity is 12,500 horse-power each, operating under the normal effective head.

THE GENERATORS were built by the Westinghouse Electric & Manufacturing Company of Pittsburg, Pa. Three are of 10,000 horse-power and three of 12,000 horse-power capacity, speed 187½ revolutions per minute, 3-phase, 25 cycles, 12,000 volts. The revolving element weighs 95 tons and the total weight is 212 tons.

THE GOVERNORS. Three were made by the Lombard Governor Company of Ashland, Mass., and three by J. M. Voith. All operate by means of oil under pressure.

THE EXCITERS are 375 kilowatt Westinghouse direct-current generators, 300 R. P. M., 250 volts, directly connected to Stillwell-Bierce and Smith-Vaile "Victor" turbines, located on the gallery overlooking the turbine floor, and supplied with water through thirty-inch penstocks that connect with the main conduit through the cable tunnel. Each of the two exciters has capacity to supply the fields of six generators. The exciter and generator rheostats, as well as the governors and field switches, are controlled either locally or from the Control Room in the Distributing Station.

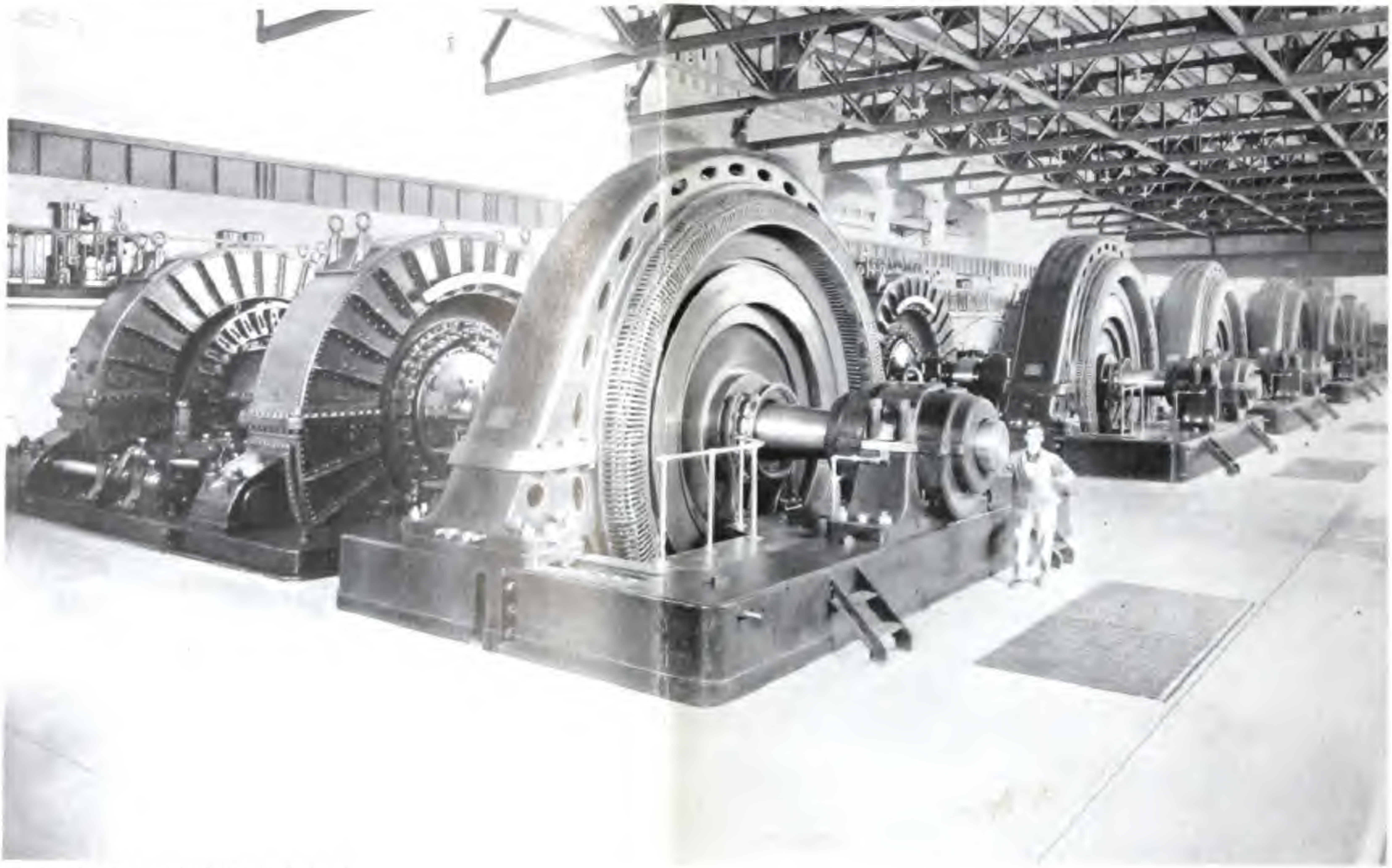
POWER DISTRI



F NIAGARA FALLS.

INTERSTATION

THE CABLE TUNNEL leads from the Generating Station to a manhole just above the main conduit. Its length is 285 feet; height, 8½ feet; breadth, 7½ feet; and it is inclined at an angle of about 30 degrees from the horizontal. The side walls of the tunnel contain tile ducts which carry the 12,000-volt, three-conductor power cables, two for each generator. The control, low



INTERIOR OF GENERATING STATION

voltage, and service wiring is carried in iron ducts suspended from the roof. On the floor, side by side, are the thirty-inch penstocks supplying the exciter turbines. From the manhole to the Distributing Station, a distance of 320 feet, the cables are carried in standard underground conduits.

DISTRIBUTING STATION

This building, of red brick with limestone trimmings, occupies a commanding position on the bluff overlooking the Gorge and Cataract. It is absolutely fireproof in construction, and contains, in addition to its electrical equipment, the offices of the Company.

THE 12,000-VOLT BUS STRUCTURE is of the semi-enclosed form, built entirely of reinforced concrete. After leaving the three-conductor cables, each wire of the system is carried in a separate compartment, entirely isolated from every other.

THE OIL SWITCHES for controlling the 12,000-volt circuits are arranged in groups corresponding to the generating units, and are operated electrically from the Control Room.

THE TRANSFORMERS are of 3,000 K. W. capacity, 12,000 to 60,000 volts, oil insulated and water cooled. They are grouped in threes, each group being separated from the others by a fireproof wall. Each transformer is enclosed in a steel tank capable of withstanding an internal pressure of 150 pounds per square inch and containing 70 barrels of oil. The normal capacity of the twelve transformers installed is 48,000 horse-power, with overload capacity of 25 per cent.

THE HIGH-TENSION BUS is of the open type of construction and is in a separate compartment away from other apparatus. Circuits leading to and from this bus are controlled by electrically operated oil switches.

THE CONTROL ROOM is a spacious apartment located high up in the center of the building, where all disturbance is reduced to a minimum and highest efficiency of operation may be had. It contains the control pedestals and indicating instrument stands corresponding to the generating and transforming units, feeder switchboards, alternating- and direct-current service switchboards, voltage regulators, and telephone switchboard. It is connected, through fireproof doors, with the other compartments of the building containing the switches, transformers, busses, etc.


DISTRIBUTING STATION

On a mezzanine floor below the Control Room are located all the recording and integrating instruments, for measuring the output of the station. On a still lower floor are relays for automatically opening the circuits in case of trouble, and the fuse and terminal boards, for the control and instrument wires.

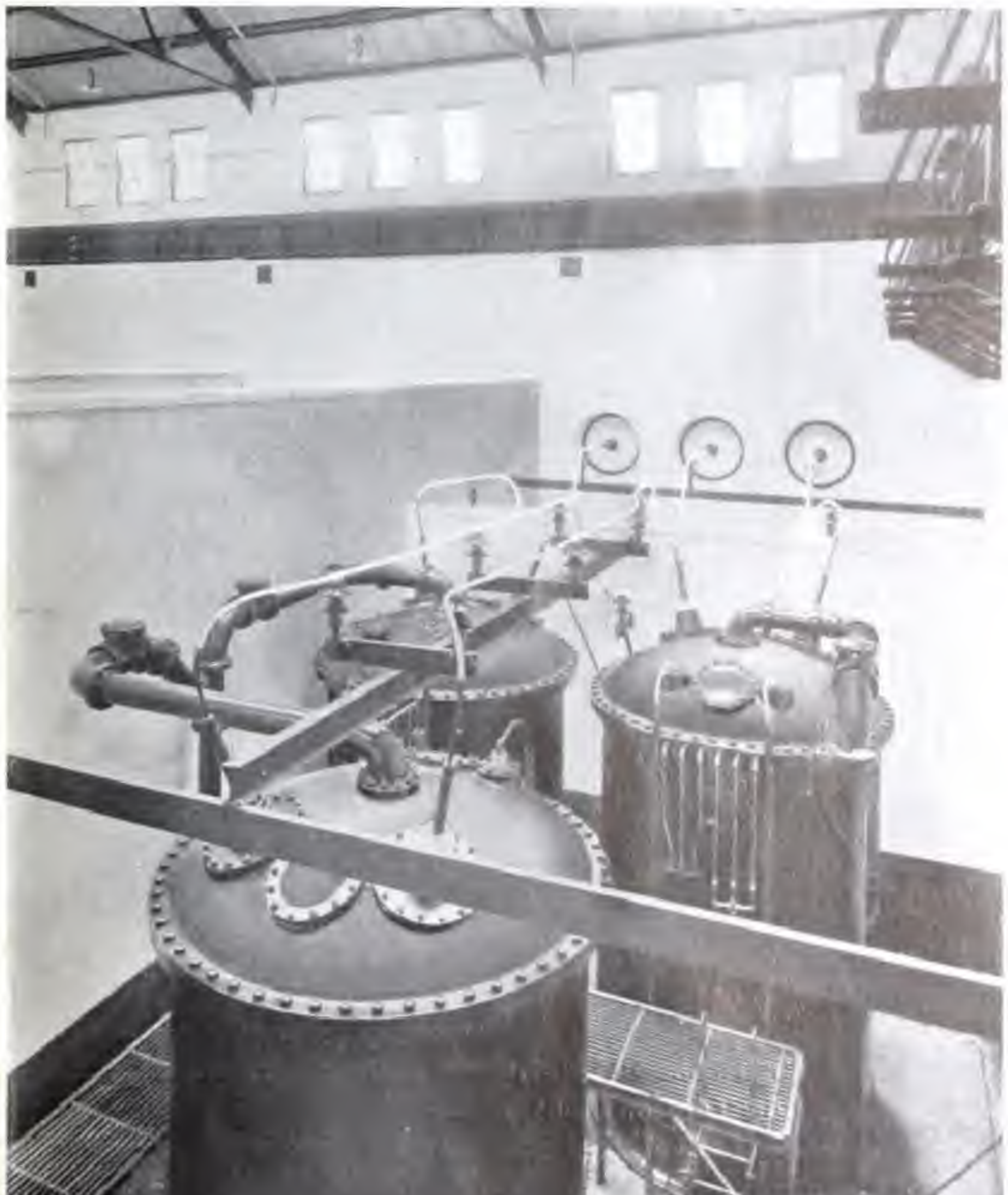
LIGHTNING PROTECTION is obtained by means of electrolytic lightning arresters, mounted on poles in the rear of the station, and choke coils between the transformers and the high-tension bus. Horn-gap arresters are also installed.

All of the electrical apparatus of the station, with the exception of the cables, etc., was furnished by the Westinghouse Electric and Manufacturing Company, much of it being especially designed for this plant.

TRANSMISSION LINES

TWO 60,000-VOLT LINES run from the Distributing Station six miles to a point on the Niagara River near the town of Queenston, where they cross the Gorge and connect with the lines of the Niagara, Lockport and Ontario Power Company, delivering power for use in the United States. These lines consist of aluminum conductors $1\frac{1}{8}$ inches in diameter, carried on steel towers 55 feet high to the top wire, with an average span of 500 feet. The insulators for this line are of porcelain and weigh 35 pounds each.

12,000-VOLT LINES are used for distribution in Canada and are carried on wooden poles. Power from these lines is now being delivered in Niagara Falls, St. Catharines, Thorold, Port Robinson, Welland and Port Colborne. The present development of these local transmission lines is about 60 miles of 3-phase circuits; and this will shortly be extended to more


VIEW IN TRANSFORMER ROOM

MAP OF TERRITORY, 500 MILES SURROUNDING NIAGARA FALLS.

WHAT THE POWER IS USED FOR

It is impossible to enumerate the manifold purposes for which the power is used, but some of the more important are the following:

LIGHT. The power generated at this station and sent out over the above named transmission lines furnishes part or all of the public and private lighting in Niagara Falls, Welland, Stamford, and St. Catharines, Ontario; and Lockport, Depew, West Seneca, Hamburg, Batavia, Rochester, Canandaigua, Auburn, Baldwinsville, Phœnix, Fulton, and Syracuse, New York.

HEAT. The same power operates electric furnaces for the reduction of iron, copper, and other ores, and the manufacture of cement, calcium carbide and lime nitrates, in Port Colborne, Welland, Niagara Falls, and Thorold, Ontario; and Lewiston, Lockport, and Caledonia, New York.

POWER. The same power operates in whole or in part the trolley systems in Syracuse, Rochester, Canandaigua, Geneva, West Seneca and Hamburg; and the interurban lines, Syracuse, Lake Shore & Northern, Syracuse & South Bay, Rochester & Geneva, Rochester & Mt. Morris (Erie Railroad), Buffalo, Lockport & Rochester, Buffalo & Hamburg, and Buffalo & Dunkirk (partly constructed). It operates the steel works of the Ontario Iron and Steel Company at Welland, Lackawanna Steel Company (7,000 employés), Shenandoah Steel Wire Company, plate rolling mills of Seneca Iron and Steel Company, and pumping works of Depew and Lake Erie Water Company at West Seneca; repair shops of the New York Central & Hudson River Railroad Company, and Delaware, Lackawanna & Western Railroad Company, and works of Gould Coupler Company at Depew; stone crushing establishment of the Kelley Island Lime and Transport Company at Akron; works of the United States Gypsum Company at Oakfield, and various smaller industries located on main transmission lines. Through the distributing systems of the light, heat, and power companies in the various cities above named in Ontario and New York, this power is applied to practically every use for which power is utilized, from sewing machines and ventilating fans to rolling mills and trip hammers.

NIAGARA AS A MANUFACTURING CENTER

The utilization of a portion of the vast energy of Niagara, without in any way detracting from the splendor or beauty of the Falls, is destined to create in the Ontario peninsula and in Western New York, a vast manufacturing district. This evolution is already in progress and every year it gains added strength. The cheapest power is to be had in the vicinity of the works, on both sides of the river, and as far as the Welland Canal on the west, and Lockport on the east. Within those limits there is abundance of cheap land for manufacturing sites, cheap power, and cheap transportation by the Welland or Erie canals or by any one of five trunk railroad lines. In this district will naturally be the home of the electro-furnaces, producing certain grades of metals and alloys, of fertilizers and other calcium products, which require power at so low a cost as to make long distance transmission impossible. Beyond this district and in the territory between Detroit on the west and Syracuse on the east, Toronto on the north, and Dunkirk on the south, there are power, cheap transportation, abundant labor and proximity to a market of more than 40,000,000 people, all living within a night's ride of Niagara. All this territory shares in the benefits of the Great Lakes bringing cheap raw materials from the West, and of all the trunk lines of railroad between Chicago and the Atlantic Seaboard for distributing the finished products. These favorable conditions have already resulted in the establishment on the Niagara frontier of steel and iron industries second only to those of Pittsburg, and of flouring mills which are a close rival to those of Minneapolis. In future years and as the electrification of the railroads progresses, these favorable conditions will make the Niagara District — on both sides of the International boundary — an unrivaled center of manufacturing industries.

CHRONOLOGY

Charter granted by Parliament of Dominion of Canada, June 23, 1887.

Charter acquired by present owners, April 9, 1900.

Ground broken for Generating Station, July 15, 1902.

Work on diverting dam — Dufferin Islands — started, August 15, 1902.

Units, Nos. 1, 2, and 3 in operation, July 1, 1905.

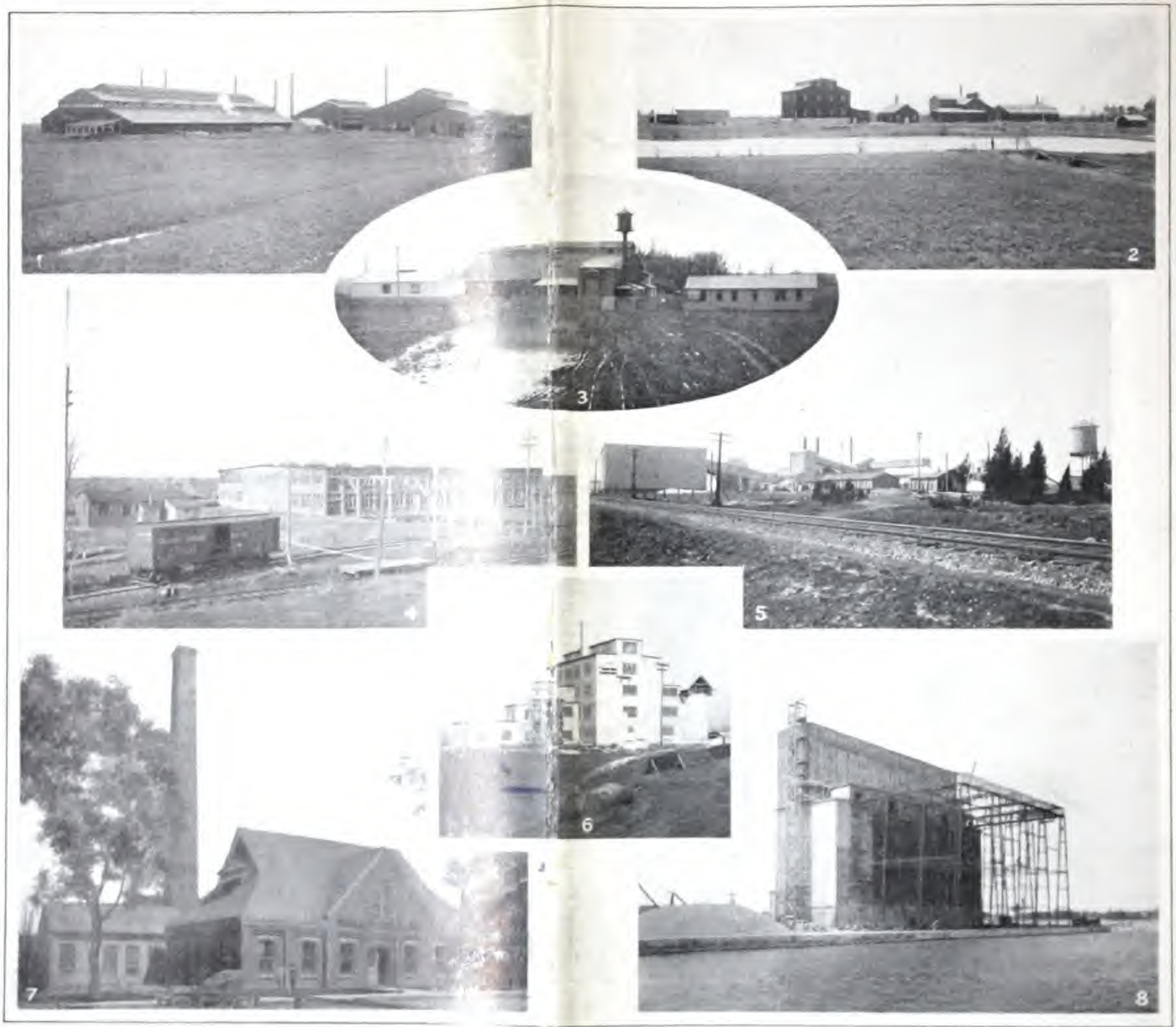
Power delivered commercially in Lockport, N. Y., November 6, 1905.

Power delivered commercially in Syracuse, N. Y., July 7, 1906.

Unit No. 4 in operation, November 5, 1906.

Power delivered commercially in Welland, Ont., November 6, 1906.

Units 5 and 6 in operation, January 18, 1908.



A FEW [illegible]TOMERS' PLANTS IN ONTARIO

1 ONTARIO IRON AND STEEL COMPANY, WELLAND
2 SMELTER AT THOROLD
3 ELECTRO METALS, LTD., WELLAND
4 CANADIAN RAMAPO IRON WORKS, LTD., STAMFORD
5 CANADIAN PORTLAND CEMENT COMPANY, PORT COLBORNE
6 CANADIAN ETHINITE COMPANY, SUSPENSION BRIDGE
7 CITY LIGHTING PLANT, NIAGARA FALLS
8 GOVERNMENT GRAIN ELEVATOR, PORT COLBORNE

THE ONTARIO POWER COMPANY OF NIAGARA FALLS

OFFICERS

JOHN J. ALBRIGHT, ... President
FRANCIS V. GREENE, ... Vice-President
ROBERT C. BOARD, . Treasurer and Secretary

DIRECTORS

JOHN J. ALBRIGHT	FRANCIS V. GREENE
EDMUND HAYES	R. K. ALBRIGHT
S. M. CLEMENT	ROBERT C. BOARD
W. H. GRATWICK	MILLER LASH

STAFF

V. G. CONVERSE, ... Engineer in Charge
W. N. RYERSON, ... Superintendent
B. R. PAINE, ... General Agent
W. L. ADAMS, ... Sales Engineer

L. L. NUNN, P. N. NUNN, Consulting Engineers, Provo, Utah

GREEN & WICKS, Architects, . Buffalo, N. Y.

Corporate Office:
Niagara Falls, Ontario.

Branch Office:
816 Fidelity Building, Buffalo, N. Y.